

## **FUNCTIONAL FEATURES OF ENGINEERING GRAPHICS OF 2D DESIGN IN AUTOCAD AND 3D MODELING IN SOLIDWORKS**

Baksa Sarajko

Polytechnic of Medimurje in Čakovec, Bana J. Jelačića 22a, sarajko\_baksa@yahoo.com

**Keywords:** *2D design, 3D modeling, engineering graphics, technical drawings*

### **SUMMARY:**

*In modern times 3D modeling has become generally accepted; engineers and designers are increasingly becoming oriented towards contemporary spatial 3D computer technology that facilitates their everyday work. The task of this paper is to determine which of the two CAD programs; Autocad or SolidWorks, is more appropriate and efficient for students and technical engineers. Identical tasks were performed by one group of students in AutoCad, and the other in SolidWorks. Relevant results will be compared to the time required to create shop drawings (top view, side view, front view, perspective, title block) of the same models in both programs, as well as the number of computer moves (clicks) needed to produce the models in question. The first research model is somewhat easier in design terms, while the other two are slightly more complex. In addition to the above mentioned, the emphasis is on the positive advantages as well as the efficiency of the 3D approach to product design, given the shortcomings and obsolescence of the 2D concept of computer engineering graphics.*

### **1. INTRODUCTION**

Nowadays life without modern technology is almost unimaginable, and it has simply become a part of our everyday life and is designed to make life easier for people and help in many things, both in leisure and business. Today, with the help of computers and numerous engineering graphics programs, we are witnessing the exceptional development of many branches, both in scientific and artistic fields.

Technical drawings have been an extremely important aspect of mutual communication in the history of mankind, even before the development of writing. Technical drawing develops during the Renaissance when technical sciences are being developed and later becomes more and more complex. Technical drawings must adhere to international standards for technical drawings, and they must be clear, well labeled and visible [1].

The basic principle of technical drawing is uniformity and simplicity. This means that the technical drawing must be clear, insightful and precise so that it is easy to determine all dimensions of the object [2]. With CAD (Computer Aided Design) programs like the ones investigated here; AutoCad and SolidWorks, engineers and designers in civil engineering, construction and other related areas can make their projects extremely easy in 2D and 3D techniques, and computer software tools enable them to make simpler and faster solutions, especially modern 3D applications of higher degree of complexity of usability analysis [3].

## 2. ENGINEERING GRAPHICS COMPUTER CAD PROGRAMS

The beginnings of CAD software engineering programs appear in the middle of the last century. In 1963, John Sutherland at MIT, Boston (Massachusetts, USA), using his Sketchpad invention, showed how it is possible to make and alter drawings on a computer controlled radar screen [4].

Given the scope of the areas covered, modern CAD computer software systems can be divided into three levels of technical comprehensiveness:

- CAD systems of low comprehensiveness. These programs are designed for making technical drawings or 2D models. They contain basic mechanisms for making wired, surface and solid spatial models, but without the possibility of parametric modeling based on features. These CAD systems include AutoCAD, Turbo CAD, etc.
- CAD systems of medium comprehensiveness. These programs include CAD systems for parametric modeling based on features that use third-party applications for numerical analysis using finite element method (*CAE, Computer Aided Engineering*) and Computer Aided Manufacturing (CAM). The lower prices of these CAD systems make them accessible to small manufacturing companies. Representatives of these CAD systems are SolidWorks, Solid Edge, AutoCAD Inventor and Mechanical Desktop.
- CAD systems of high comprehensiveness. These systems are built modularly, and it is possible to buy individual modules and not necessarily complete systems. They use parametric modeling based on features. Depending on the scope of the purchased modules, these systems can be very expensive, especially for small manufacturing companies. These systems have largely been developed for the needs of large companies. Representatives of these CAD systems are Catia, Pro/ENGINEER and NX by Siemens [5].

## 3. USED COMPUTER PROGRAMS

When analyzing functional features of engineering graphics in computer aided technical drawing within the technical domain, two CAD programs were used for traditional 2D design and modern 3D design; 2D program of low comprehensiveness AutoCAD and 3D SolidWorks program of medium comprehensiveness. In addition to the above-mentioned CAD programs, additional software, Auto Mouse Clicker or Click Counter, were also used to determine the total number of clicks and time needed to produce analyzed program tasks.

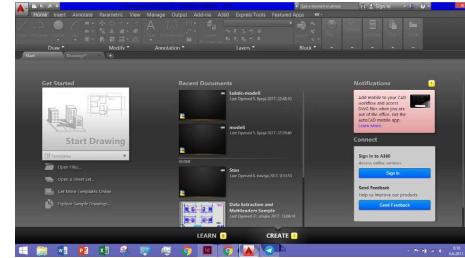
### 3. 1. AutoCAD ENGINEERING GRAPHICS PROGRAM

AutoCAD, Figure 1, a low comprehensiveness system is the oldest and most recognized computer aided design toolkit, first released in December 1982 by Autodesk, which offers over 75 specialized software tools and utilities. The biggest advantage is the sophisticated two-dimensional, broad-based project design tool, and in the latest version of the program and three-dimensional (2,5D) design. Two-dimensional design replaces classical "school" design on paper with drawing tools, while three-dimensional design provides the ability to zoom, rotate, and perspective in different projections regardless of direction [4].

Workspace, Figure 2, in Autocad is a space for 3D modeling and an arbitrary number of layouts that can be used in the 'Paper' and 'Model' mode. In the 'Model' mode on the layout, you can open projections and viewports on a three-dimensional model created in the modeling space. In the 'Paper' mode, layouts do not have any correlations with the three-dimensional model, and in that view the views (if they are even created) can not be activated. The model and paper space are in principle used separately, i.e. they are not organized on the same layout [6].



**Figure 1:** AutoCAD 2016 Program Logo



**Figure 2:** Overview of the initial interface

With traditional 2D use of AutoCAD, this program uses a standard XY coordinate system with a horizontal X axis and a vertical Y axis. In each new drawing, AutoCAD displays the X and Y axes (0,0) in the lower left corner of the drawing, which can sometimes help with the positioning of the drawing on the layout itself, since it is easiest to start drawing from a starting point. Also significant are layers that serve to separate drawing of different units, which make the whole drawing by overlapping. It is possible to turn-off and turn-on layers depending on where each part is being drawn, so if only one part of the drawing is being drawn, other parts are not in the way. Each command is also easy to find by typing its name in the command line at the bottom of the layout [7, 8].

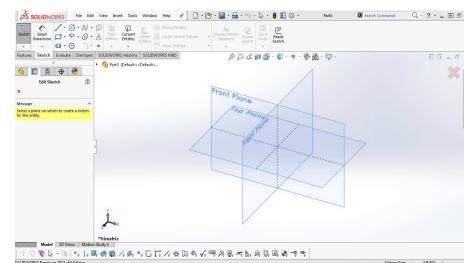
AutoCAD is a program which is most criticized for its complexity, and the period of time that is required for each model or drawing, which can be deduced from the time periods required for the creation of design models [9].

### 3. 2. SolidWorks ENGINEERING GRAPHICS PROGRAM

Solidworks is a computer-based CAD/CAE (*Computer Aided Engineering*) program that is running on the Microsoft Windows platform. Figure 3 shows the Solidworks logo, with the view of the starting interface in Figure 4.



**Figure 3:** Solidworks Software Logo



**Figure 4:** View of the starting interface

The program was created by Dassault Systemes and was formed within the SolidWorks corporation established in December 1993 at the initiative of John Hirschick, a graduate of the Massachusetts Institute of Technology. By 2013, over 2 million engineers and designers were using it in more than 165.000 companies around the world. The program enables faster and more efficient 3D modeling as well as two-dimensional drawings. It requires a shorter learning time for beginners. By knowing how to make a single model, it is also possible to make more extensive tasks, and more complex models. The program is more modern than the others and it is easier to use, as well as to develop certain models of static and dynamic analysis of mechanical moments needed in a variety of real-world situations [10, 11].

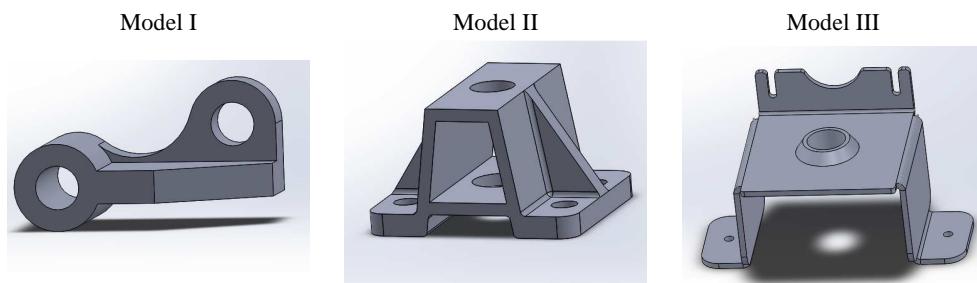
At this point, Dassault Systemes has completed the CAD/CAM/CAE SolidWorks system with the following options, which put it among the high-end program systems;

- SolidWorks Professional - Includes all SolidWorks Standard packages, and it complements it with new capabilities like the product data management system and the photo-realistic rendering module. Also, the Professional version of SolidWorks has a large base of machine elements, software tools that will automatically calculate production costs, and also includes fault detection modules for designs,
- SolidWorks Premium - Includes full SolidWorks Professional functionality with additional simulation and analysis modules, and advanced command lines for drawing line elements such as pipes and cables,
- SolidWorks Standard - software package has basic and advanced modules for a variety of industries. It includes modules for working with surfaces, sheet metal flat patterns, structural welded assemblies, and modules for complex surfaces,
- The SolidWorks Electrical - package offers a wide range of electrical system design tools. This package is primarily for professional designers who will convert their 2D schematics to a 3D space and thus have their link in contemporary project documentation,
- SolidWorks Electrical 3D - in addition to the basic SolidWorks Electrical package, there is a suite of tools for 3D design of electrical machine elements and their connection. The system, among other things, calculates the required length of wires, cables and quantities of el.material.
- SolidWorks Electrical Professional - package includes tools for developing and designing 2D electrical schematics as well as integration with a 3D system for further processing of electrical components.

SolidWorks currently has several versions of CAD software in addition to eDrawings, eDrawings Viewer, eDrawings Professional Collaboration Tools, as well as DraftSight, a 2D CAD product [12].

#### 4. RESEARCH METHODOLOGY

The main task of this research is to detect time and workflow during work in two conceptually different CAD programs, 2D AutoCAD and 3D SolidWorks, in which it was necessary to draw up a technical drawing for three spatial models of different levels of complexity, Figure 5.



**Figure 5:** Perspective views of analyzed 3D models

It was necessary to determine the total number of clicks for which computer programs Auto Mouse Clicker and Click Counter were used, which also served to detect the time needed to create the drawings. Students have joined the experimental work, 22 students were performing assignments in AutoCAD, and 22 students in SolidWorks. After the completion of the work, it was necessary to explain how a particular model was created, tools and actions that were used during the design, and to find solutions within the CAD application simpler and faster, accordingly the time spent on making the model as well as its complexity and technical accuracy, need to be taken into account.

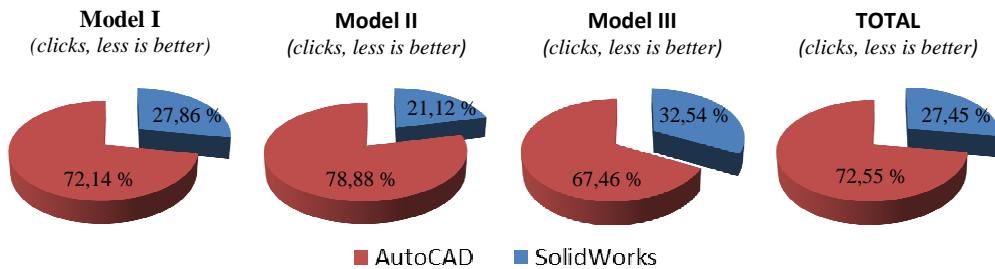
## 5. RESEARCH RESULTS

Within Table 1 is a list of minimum, average and maximum values of analyzed parameters, time and working number of computer clicks required to produce technical documentation of the models in question.

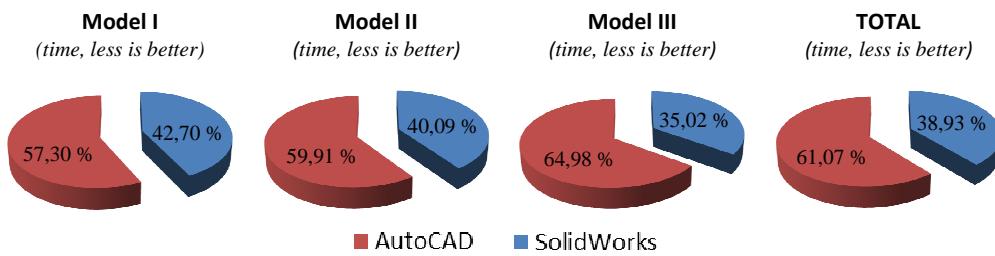
**Table 1:** View of the minimum, average, maximum time, and the required number of clicks

CAD Program		Model I		Model II		Model III		UKUPNO	
		Clicks (Number)	Time (min)						
Solid Works	Min.	230	15	367	15	397	40	994	70
	Ave.	373	76	396	89	725	83	1494	248
	Max.	480	180	417	210	806	180	1703	570
Auto CAD	Min.	132	30	903	38	238	57	1273	125
	Ave.	966	102	1479	133	1503	154	3948	389
	Max.	1253	246	2156	321	2596	332	6005	899

The graphical presentation in Figure 6 shows percentages (less is better) of the average number of working clicks required, and in Figure 7 the percentages of the average time spent on producing the technical documentation of the models in question.



**Figure 6:** Graphical presentation of the percentage share of the number of clicks analyzed 3D models



**Figure 7:** Graphical presentation of the percentage share of the time required to produce 3D models

## 6. CONCLUSION

After the research we have come to the conclusion that work in CAD applications for students is quite demanding and requires a lot of time, effort and concentration, especially students who do not come from technical schools, and computer skills and patience are also desirable as the programs are exceptionally "complex, complicated and somewhat unintuitive", so it is very difficult for beginners to get around in them, especially in the AutoCAD computer application.

Based on the conducted research it can be concluded that a technical drawing can be accurately and precisely drawn in the CAD program AutoCAD in all its 3 dimensions, as well as the perspective and all legally prescribed title blocks. It was concluded that AutoCAD is a good drawing program for 2D drawings, but not for spatial views. Other modeling software, of a higher complexity levels, such as SolidWorks, do this job much faster and better.

Looking at today's AutoCAD technology achievements it is far behind of full 3D modeling, in terms of time, performance and way of working, and an increase in the percentage of work clicks of 265% for the production of analyzed 3D models compared to working in SolidWorks.

Student conclusions show that AutoCAD as a top program, although by some users and professions considered outdated and can be outperformed by some of the better programs, continues to be widely used as an excellent basic tool for 2D drawing, but at the same time its exceptional complexity in creating a 3D model display perspective within a 2D interface makes it an outdated program that is difficult to work with, where a lot of time is wasted, or where making some positions and drawings is extremely complex, especially in perspective. To complete the required task, some of the students have found solutions in alternatives, using secondary, primitive 3D modelers, for example SketchUp. On the contrary work of Solidworks, by all actors, has really shown how a technical drawing can be made easily, easily, practically and quickly.

Based on the detected advantages of working in two conceptually different program tools, disadvantages with which the respondents met were determined, and precisely in this regard, the differing observational results, in addition to the time spent and the number of interventions required, were significant in the analysis and selection of a more suitable program tool. We conclude that 3D SolidWorks is a much easier and faster, with an established increase in efficiency of 157%, and that the 2D technology conceptually present in AutoCAD can not meet the specific needs of engineers, constructors and designers of today's technical professions, especially in terms of speed and quality of work.

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